IN THE CLAIMS

1. Apparatus for detecting earthquake generated P-waves comprising:

means forming a housing adapted to be mounted to a supporting structure subject to movement by seismic forces;

sensor means affixed to said housing and operative to generate electrical signals proportional to motion experienced by said support structure;

signal amplifying and filtering means responsive to said electrical signals and operative to amplify and pass signals having frequencies within the range of approximately 0.5 to 15 Hz; and signal processing means for sampling the passed signals and for performing an automatic real-time offset zeroing function by averaging the signals over successive periods of time greater than approximately 10 seconds, and for taking the ongoing mean of the averaged signals as the zero point, but causing the averaged signal to drop to a "zero" value after a few seconds of no signal, and for determining that a P-wave has been detected if (a) the averaged signal rises above a predetermined level, and/or (b) the integrated sum rises above a predetermined trigger value within a predetermined window of time, and for generating an output signal commensurate therewith.

2. Apparatus for detecting earthquake generated p-waves as recited in claim 1 wherein said sensor means includes a thin-film, cantilevered, piezo-electric sensor element having a proximal extremity rigidly affixed to said housing and an unsupported distal extremity.

3. Apparatus for detecting earthquake generated P-waves as recited in claim 2 wherein said sensor element has a weight of a predetermined mass affixed to said distal extremity.

4. Apparatus for detecting earthquake generated P-waves as recited in claim 1 wherein said sensor means includes multiple sensor elements each of which is responsive to motion in a direction normal to one of a corresponding plurality of mutually orthogonal intersecting planes and operative to generate an electrical signal commensurate therewith.

5. Apparatus for detecting earthquake generated P-waves as recited in claim 4 wherein each said sensor element includes a thin-film, cantilevered, piezo-electric structure having a proximal extremity rigidly affixed to said housing and an unsupported distal extremity.

6. Apparatus for detecting earthquake generated P-waves as recited in claim 5 wherein each said sensor element has a weight of a predetermined mass affixed to its distal extremity.

7. Apparatus for detecting earthquake generated P-waves as recited in claim 5 wherein said housing includes a printed circuit board including electrical traces interconnecting said sensor means, said signal amplifying and filtering means and said signal processing means.

8. Apparatus for detecting earthquake generated P-waves as recited in claim 7 wherein each said sensor element is enclosed in an airtight enclosure.

9. Apparatus for detecting earthquake generated P-waves experienced by a monitored structure, comprising:

sensor means for attachment to the monitored structure and operative to generate electrical signals proportional to motion experienced by said structure;

signal amplifying and filtering means responsive to said electrical signals and operative to pass signals having frequencies within the range of approximately 0.5 to 15 Hz; and

signal processing means for performing real-time digital signal processing on said passed signals, the processing including real-time offset zeroing, multiple-order low-pass digital filtering, and digital integration that keeps an ongoing sum of the previous few seconds of incoming readings and then causes the sum to fall to a zero value after a few seconds of no signal activity.

10. Apparatus for detecting earthquake generated P-waves as recited in claim 9 wherein the real-time offset zeroing is accomplished by repetitively averaging the passed signals over periods of time greater than approximately 10 sec. and taking the ongoing mean as the zero point.

11. Apparatus for detecting earthquake generated P-waves as recited in claim 10 wherein said processing means generates a first signal if a detected p-wave has a magnitude falling within a first Richter scale range, and generates a second signal if a detected P-wave has a magnitude falling within a second Richter scale range.

12. Apparatus for detecting earthquake generated P-waves as recited in claim 11 wherein said sensor means includes a thin-film, cantilevered, piezo-electric sensor element having a proximal extremity rigidly affixed to said housing and an unsupported distal extremity.

13. Apparatus for detecting earthquake generated P-waves as recited in claim 12 wherein said sensor element has a weight member of a predetermined mass affixed to said distal extremity.

14. Apparatus for detecting earthquake generated P-waves as recited in claim 9 wherein said sensor means includes multiple sensor elements each of which is responsive to motion in a direction normal to one of a corresponding plurality of mutually orthogonal intersecting planes and operative to generate an electrical signal commensurate therewith.

15. Apparatus for detecting earthquake generated P-waves as recited in claim 14 wherein each said sensor element includes a thin-film, cantilevered, piezo-electric structure having a proximal extremity rigidly affixed to said housing and an unsupported distal extremity.

16. Apparatus for detecting earthquake generated P-waves as recited in claim 15 wherein each said sensor element has a weight member of a predetermined mass affixed to its distal extremity.

17. Apparatus for detecting earthquake generated P-waves as recited in claim 15 and further comprising:

a printed circuit board including electrical traces interconnecting said sensor means, said signal amplifying and filtering means and said signal processing means.

18. Apparatus for detecting earthquake generated P-waves as recited in claim 17 wherein each said sensor element is enclosed in an airtight enclosure.

19. A method of detecting earthquake generated P-waves comprising the steps of:

detecting seismic motion and generating corresponding motion signals;

amplifying and filtering said motion signals and passing signals having frequencies within the range of approximately 0.5 to 15 Hz;

performing a real-time offset zeroing function by averaging the signals over successive periods of time greater than approximately 10 seconds and for taking the ongoing mean of the averaged signals as the "zero" point, but causing the averaged signal to drop to a "zero" value after a few seconds of no signal; and

determining that a P-wave has been detected if (a) the averaged signal rises above a predetermined level, and/or (b) the integrated sum rises above a predetermined trigger value

within a predetermined window of time, and for generating an output signal commensurate therewith.

20. A method of detecting earthquake generated P-waves as recited in claim 19 wherein said processing means generates a first signal if a detected P-wave has a magnitude falling within a first Richter scale range, and generates a second signal if a detected P-wave has a magnitude falling within a second Richter scale range.

21. Apparatus for detecting earthquake generated P-waves as recited in claim 1 wherein said signal processing means includes a user interface for allowing modification of the ground acceleration and power spectral density output trigger levels and the internal digital signal processing filter values that are used by the system to determine the presence of an impending earthquake.

22. Apparatus for detecting earthquake generated P-waves as recited in claim 9 wherein said signal processing means includes a user interface for allowing modification of the ground acceleration and power spectral density output trigger levels and the internal digital signal processing filter values that are used by the system to determine the presence of an impending earthquake.

23. Apparatus for detecting earthquake generated P-waves as recited in claim 1 wherein said signal processing means operates by

detecting seismic motion and generating corresponding motion signals;

amplifying and filtering said motion signals and passing signals having frequencies within the range of approximately 0.5 to 15 Hz;

performing a real-time offset zeroing function by averaging the signals over successive periods of time greater than approximately 10 seconds and for taking the ongoing mean of the averaged signals as the "zero" point, but causing the averaged signal to drop to a "zero" value after a few seconds of no signal; and

determining that a P-wave has been detected if (a) the averaged signal rises above a predetermined level, and/or (b) the integrated sum rises above a predetermined trigger value within a predetermined window of time, and for generating an output signal commensurate therewith.

24. Apparatus for detecting earthquake generated P-waves as recited in claim 23 wherein said signal processing means generates a first signal if a detected P-wave has a magnitude falling within a first Richter scale range, and generates a second signal if a detected P-wave has a magnitude falling within a second Richter scale range.

25. Apparatus for detecting earthquake generated P-waves as recited in claim 9 wherein said signal processing means operates by

detecting seismic motion and generating corresponding motion signals;

amplifying and filtering said motion signals and passing signals having frequencies within the range of approximately 0.5 to 15 Hz;

performing a real-time offset zeroing function by averaging the signals over successive periods of time greater than approximately 10 seconds and for taking the ongoing mean of the averaged signals as the "zero" point, but causing the averaged signal to drop to a "zero" value after a few seconds of no signal; and

determining that a P-wave has been detected if (a) the averaged signal rises above a predetermined level, and/or (b) the integrated sum rises above a predetermined trigger value within a predetermined window of time, and for generating an output signal commensurate therewith.

26. Apparatus for detecting earthquake generated P-waves as recited in claim 1 wherein said signal processing means wherein said processing means generates a first signal if a detected P-wave has a magnitude falling within a first Richter scale range, and generates a second signal if a detected P-wave has a magnitude falling within a second Richter scale range.

27. An earthquake detection system comprising:

a plurality of P-wave detection stations respectively disposed in locations remote from each other and communicatively connected together by at least one type of communications medium;

each said station including a pair of P-wave detectors, for attachment to a structure in spaced apart disposition, and a controller responsive to detection signals developed by said detectors and operative to generate alarm signals in the event said detectors both detect a P-wave and simultaneously generate detection signals; and

each said detector including

means forming a housing adapted to be mounted to a supporting structure subject to movement by seismic forces;

sensor means affixed to said housing and operative to generate electrical signals proportional to motion experienced by said support structure;

signal amplifying and filtering means responsive to said electrical signals and operative to amplify and pass signals having frequencies within the range of approximately 0.5 to 15 Hz; and

signal processing means for sampling the passed signals and for performing an automatic real-time offset zeroing function by averaging the passed signals over successive periods of time greater than approximately 10 seconds, and for taking the ongoing mean of the averaged signals as the zero point, but causing the averaged signal to drop to a "zero" value after a few seconds of no signal, and for determining that a P-wave has been detected if (a) the averaged signal rises above a predetermined level, and/or (b) the integrated sum rises above a predetermined trigger value within a predetermined window of time, and for generating a detection signal commensurate therewith.

28. An earthquake detection system as recited in claim 27 and further comprising:

a monitoring station communicatively coupled to said detection stations and operative to record detection signals and/or alarm signals generated by said detection stations.